THE

AGRICULTURAL LEDGER.

1897—No. 8.

MANURES AND MANURING.

(INDIAN MANURES.)

[*DICTIONARY OF ECONOMIC PRODUCTS, Vol. V., M. 237-59.*]

INDIAN MANURES: THEIR COMPOSITION, CONSERVATION, AND APPLICATION.

A Note by DR. J. W. LEATHER, *Agricultural Chemist to the Government of India.*

Other PAPERS that may be consulted:

The Agricultural Ledger Nos. 20 of 1893; 3, 7 and 9 of 1894; 4 and 16 of 1895; and No. 5 of 1897.

CALCUTTA:
OFFICE OF THE SUPERINTENDENT, GOVERNMENT PRINTING, INDIA.
1897.

The objects of THE AGRICULTURAL LEDGER are:—

(1) To provide information connected with agriculture or with economic products in a form which will admit of its ready transfer to ledgers;

(2) To secure the maintenance of uniform ledgers (on the plan of the Dictionary) in all offices concerned in agricultural subjects throughout India, so that references to ledger entries made in any report or publication may be readily utilised in all offices where ledgers are kept;

(3) To admit of the circulation, in convenient form, of information on any subject connected with agriculture or economic products to officials or other persons interested therein;

(4) To secure a connection between all papers of interest published on subjects relating to economic products and the official Dictionary of Economic Products. With this object the information published in these Ledgers will uniformly be given under the name and number of the Dictionary article which they more especially amplify. When the subject dealt with has not been taken up in the Dictionary, the position it very possibly would occupy in future issues of that work will be assigned to it.]

(*Agricultural Series, No. 21.*)

THE AGRICULTURAL LEDGER.

1897—No. 8.

MANURES AND MANURING.

(INDIAN MANURES.)

[*Dictionary of Economic Products, Vol. V.*, M. 237-59.]

INDIAN MANURES: THEIR COMPOSITION, CONSERVATION, AND APPLICATION.

A Note by DR. J. W. LEATHER, *Agricultural Chemist to the Government of India.*

The ordinary Indian cultivator cannot afford to purchase manures from other countries, and the consumption of such materials is limited to a small amount required by planters. It may be said, in considering the manure supply of the Empire, that it consists almost entirely of materials produced in India. On the other hand, it is not to be assumed that there is no trade in manures, and although this trade possibly may not bear any large proportion to the total amount utilised, still it is a quantity which has to be reckoned with. Very large amounts of city manure, and considerable amounts of oilseed refuse of a non-edible nature, are certainly regularly bought by the cultivator.

Object of the paper.

2. The object of this paper is to set out what information exists on the subject of the several manurial materials which are available in India and, at the same time, to show what further information might be obtained regarding these materials and the importance of that enquiry.

Indian manures.

3. The materials which are more or less available to the Indian cultivator may be included in the following list:—

1. Cattle Dung and Urine.
2. Cattle Bedding materials.
3. Night-soil and other city refuse.
4. Oilseed refuse.
5. Bones.
6. Saltpetre.

7. River, Canal and Tank silt.
8. Green manures.
9. Influence of Leguminous crops.
10. Sheep folding.

Methods of value of manures.

In discussing the value of a manurial material two items of information are of importance. The one is its value as a manure, the other the amount available. The first of these may be appraised by its market value, or it may be valued according to the increase of a crop or crops which is found to be due to it. The former method, namely, the market value, depends on the supply and demand for the time being, and will consequently vary considerably even in short periods of time as will become particularly evident when considering the oilseed refuse; the second method is one which is entirely independent of such fluctuations and may be said to be of an *absolute* nature for any particular area which enjoys substantially the same climate, and experiments are being conducted at different Experimental Farms for the purpose of determining this value for a number of materials. Climate *may* cause a manurial material to be more valuable in one part of the Empire than in another, in that a larger increase of crop may be obtained from a certain amount of manure in one part than in another. The information available is, however, too slight to admit of much being said on this point.

Experimental Stations in India.

4. In India there are at present the following Experimental Stations, at which, among other operations, the agricultural value of different manures is being determined: Poona, Nagpur, Cawnpur, Dumraon, and Burdwan. At each of these some experiments are now in progress which, it is anticipated, will eventually show what value may be placed on the several materials named in paragraph 2. But, although in several cases the experiments have now been in progress for some 10 or 12 years, the majority of the experiments have not been carried on for a sufficiently long period to allow of them being considered complete.

Amount of manure available.

5. A knowledge of the relative amounts of the several manurial materials available in India is naturally of importance; for from it may be deduced the relative importance of each. This information is, however, not easily obtained, and at the most only rough estimates can be arrived at.

I.—CATTLE DUNG AND URINE.

Value of cattle manure.

6. At all the Experimental Farms named in paragraph 4, cattle manure is being applied to various crops, and the experiments have now been in progress for some years. Until recently, however, the manure was badly cared for and no attempt to imitate European example was followed. It was held by some that cattle would suffer in various ways, such as from sore feet, if kept in sheds with bedding beneath them, and although others had shown this to be a fallacy, the fact remained that at the Cawnpur and the Bengal Farms no such thing as conserving cattle manure was attempted. What was collected for use on the farms was merely the solid excrement which

was kept in a hole. The urine was entirely lost. Thus the experiments at these farms may be said to have been carried out with the solid excrement only. At Nagpur much more care was bestowed and the manure obtained has been of good quality. In *The Agricultural Ledger* No. 9 of 1894 (Agricultural Series, No. 7), I have set out in detail what were the results of the experiments on the value of cattle manure which have been in progress at the four farms named above, and it would serve no useful purpose to reproduce the contents of that paper here. The additional information since gained verifies the results there detailed; the increase (since 1893) due to cattle manure has been somewhat above the average owing to the seasons having been generally favourable. The general conclusion which one may draw from these experiments is that, with an application of about 6 tons per acre of cattle manure, there will be obtained an increase of some 300 or 400lb of wheat per acre in the North-Western Provinces or Bengal. At Nagpur the results are somewhat discordant owing to the serious attacks of rust which have been experienced, but generally there has been an increase of 200—300lb of grain. In the case of maize an increase of 400—500lb may be depended upon in any average good year, though the crop is more liable to suffer damage from bad weather than is the case with wheat, and in that case the gain will not be so great. The information in the case of rice is too uncertain to allow of safe deductions. It may be indeed that it is not true economy in most parts of India to apply cattle manure for rice at all. This point will be referred to again in a future paragraph.

Amount of cattle manure available to the ryot.

7. In paragraph 13 of *The Agricultural Ledger* referred to, I pointed out that the value of the results of these experiments very much depends on whether the amount of cattle dung employed, namely, about 6 tons per acre, is one which a cultivator may be said to have at hand.

A rough estimate of the amount of cattle manure may be obtained if we either weigh the quantity produced by cattle in a village or that produced at the farms. I have obtained information by both methods. When on tour in Ondh in December 1894, I collected and weighed the dung of several herds of grazing cattle. The herd was in each case kept for 24 hours within a moderate area. The weights are as follows:—

Instances.

(1) Herd of 50 cattle gave an average of 16·79lb per head per day, or 6,132lb per annum.
(2) Herd of 49 cattle gave an average of 13·68lb per head per day, or 5,000lb per annum.
(3) Herd of 25 cattle gave an average of 15·81lb per head per day, or 5,767lb per head per annum.
(4) Herd of 43 cattle gave 10·87lb per head per day, or 3·967lb per head per annum.

The mean of these four experiments is 5,216lb per head per annum. The herds consisted of bullocks, cows, and calves, and they received a ration of straw in addition to the grass they grazed, which I was assured is the usual custom. These herds did not contain the working

cattle, they consisted of the idle ones, young stock and milch cows of the villages. Weighments at the farms give the following results.

At the Cawnpur Farm, the mean weight of dung from the work cattle over a period of 17 months was 4,048lb per head per annum, for the *night* period only; that of the day time being excluded, because it was assumed that it would in the case of a cultivator be either dropped on the road or in the field.

At Dumraon the mean weight obtained over a period of 2 years and 3 months was 5,258lb per head per annum; in this case likewise only the night's manure being weighed.

In both cases the manure was weighed after remaining in the pit, until the manure was required for the fields. The weight of the bedding and urine at Cawnpur was equal to 1,687lb per head per annum when taken from the pit.

8. Regarding the weight of manure from the grazing cattle it might be urged that it will count for nothing, because it is dropped on the grazing area, and that, consequently, it will not be collected. This is at least what I myself should have expected would be the case. In practice it is the reverse. When I collected the first herd in Oudh, I went over the ground carefully to see that all old manure should be removed and so not included in the manure of the day of the experiment, but, to my surprise, there was *none at all!* It had all been collected and carried away for fuel. If the people can find time to take it for one purpose, they can take it for another, and consequently, one may assume that, not only the manure of the work cattle, but also that of the grazing cattle, might be used for the crops.

The amounts of manure as above detailed show that each head of grazing cattle (which includes cows and young stock) will produce about 2½ tons of manure, and that the work cattle will (during the night only) produce not less than 2 tons.

Amount of Cattle Dung per acre.

9. Now, since the question which we desire to form an opinion upon is, whether 6 tons of cattle manure is an amount which may be fairly supposed to be available for the land, it is necessary to consider over what area this manure might be applied if it were all preserved carefully. It will be allowed in the first place that one would not, in ordinary practice, manure every crop alike.

English practice.

In England a part of the agricultural economy practised consists in definite systems of "rotation." A very common rotation consists in growing roots, barley, grass and clover, wheat, in the order named, and the various other rotations adopted of a less definite character consists essentially in alternating roots and leguminous crops with cereals. In the case of the "Norfolk" rotation (roots, barley, grass, wheat) manure is always applied to the root crop and sometimes for the wheat, the barley is frequently manured indirectly because roots are often fed to cattle and sheep on the land; the grass or leguminous crops are grown with no additional manure.

Indian practice.

For India it may be said that the "Garden" crops generally or always receive manure, and that for sugar-cane and opium manure is nearly always applied, and it is also probable that this is a good rule to adopt. Certainly in the case of sugar-cane and potatoes it pays

well to manure heavily. But for the other crops, *e.g.*, wheat, maize and the millets generally which occupy much the greater area (excluding rice), we have little or no information as to any common practice. It is usual in many parts to grow a *rabi* crop one year, and a *kharif* crop the next, on the same land.

A very common practice, more especially in Behar and the North-Western Provinces, is to grow the vegetables (or "garden" crops) close to the village site, and it is this area which receives the main portion of the "house-refuse" manure. In other parts, however, such as in Gujerat, the people live a great deal away from the village during the dry season. They set up a thatched hut and remain there until the crops are reaped. ' Under such circumstances the " House " manure becomes distributed over a much larger area—a system infinitely better than the one so common in the North-Western Provinces.

Cattle Dung not the only manure.

10. Then, again, cattle manure is not the only manure generally available. Of night-soil and house-refuse there is probably as large an amount in any village or hamlet as of cattle manure, and there is frequently some tank mud in addition. Leaving out of account the latter, and assuming the "house manure" to be equal in amount to the cattle manure, we may say that the latter might form (if it were not required for fuel purposes) about one half of the manure supply of any village.

Crops not requiring manure.

11. We may assume, however, that it is not good economy to manure pulses. Our general knowledge of these crops indicates that they can do better without manure than can the cereals and millets. In the case of the rice crop also there is some evidence, which will be dealt with under the chapter on River and Canal Silt, indicating that this crop also can get along better without manure than the cereals. We have then left, the area under cereals, millets, sugar-cane and garden crops to consider. Considering that the "house" manure may be valued as equal to the "cattle" manure, we may, without using any unfair argument, assume one half of the above crops to be manured with house manure and one half remains which might be manured with cattle manure.

Crops which require manure.

Area.

12. In 1893-94 the total nett area in the North-Western Provinces under all crops was 25,503,312 acres. From this we may deduct the areas under rice (5,033,689), gram (2,187,565), half of the area under "pulses, etc." (5,895,135), indigo (348,775), and orchards (219,783), leaving an area of about 12,000,000 acres which would be much benefited by manure. The number of work cattle in these Provinces is 7,250,000, each of which may be assumed to produce 2 tons of manure per annum (in the night only), there are also some 10,000,000 other idle cattle, each of which will produce about 2½ tons of manure per annum; the total available supply being thus close on 40,000,000 of tons; and this, if we assume it to be used for half the crops requiring manure, is equal to more than 6 tons per acre. Thus, assuming the method of calculation adopted not to be open to any too great error, it must be admitted that the rate of manuring, which has been adopted at the farms, is not too high.

Number of Cattle.

Weight of manure per acre.

Objections to the calculations. Manure required for fuel.

13. At the same time objections may easily be taken to the foregoing calculations. First and most important of all is the fact that, at present the manure is largely required as fuel, and so long as this practice is adhered to, the manure cannot be employed to raise crops. As to this question about which opinions differ so largely, only one thing can be asserted, and that is that there *are* parts of India where no cattle manure (or at least very little) is burnt at all (Gujerat, Muzaffargarh, Dera Dun are examples which have come under my observation); and, secondly, that in at least one part (Gujerat) the people grow their own fuel along the field borders, and it can certainly *not* be said that this is impossible elsewhere. More than this I shall not say. My object is to show what the cattle manure is worth. Then, again, it may be asked whether the evidence adduced above as to the weight of cattle dung is sufficient to form such an estimate upon? There is, however, additional evidence from other farms. At Burdwan the weight of dung produced by 6 bullocks (during the night) over a period of about 10 months was equal to 3,721lb per head per annum. At Nagpur it amounted to 11,630lb per head per annum. At Poona the dung collected from the dry milch cattle and young stock during 4 months was equivalent to 6,380lb per head per annum. Thus, whilst the weight of manure obtained at Burdwan was somewhat less than at Cawnpur and Dumraon, at Nagpur it was far more, and it was also much more at Poona. Then, too, when on tour in Gujerat, Mr. Middleton, Professor of Agriculture, Baroda, helped me to estimate the amount of cattle manure used in one of the villages. It came to about 4,800 tons per annum. About 1,000 tons had to be brought from outside, leaving some 3,800 tons produced by the village cattle. The latter numbered 1,000 which gives an equivalent of 3·8 tons per head per annum. This evidence tends to show that the weight of manure obtained at Cawnpur and Dumraon was not anything unusual; it must be allowed to be a fair estimate.

Evidence in support of weight of Cattle Dung.

Area adopted is probably a fair one.

Finally, regarding the area taken, namely, one half that occupied by cereals, millets, oilseeds, sugar-cane, and garden produce, it is of course merely adopted to enable one to form some idea of what area there is which it might be desirable to manure. It must not be assumed that one would manure all crops uniformly. It will probably pay better to manure some much more liberally than others. On this point we have too little evidence to admit of going into much detail. On the other hand, it must be recollected that no account has been taken of the fact that the Cawnpur experiments have shown a distinct advantage to the wheat crop exerted by a previous leguminous one, the latter being removed. The results will be dealt with in detail in a later paragraph. There is some irregularity in the results, but generally a distinct, and in some cases a very considerable, increase in the wheat crop has been experienced. Such evidence is not novel. It is well recognised in Europe and the cause is now well understood. The area occupied by leguminous crops in India is very large, and since they thus probably exert a "Manurial" influence, that influence must be assumed to be exerted on a part at least of the area under cereals, etc., leaving probably a smaller area than the one

adopted in paragraph 12 to rely on cattle manure. The experiments on the value of cattle manure at the farms must, on the whole, be allowed to be of a practical nature, and that the rate of manuring is one which may in ordinary practice be realised.

Composition of Cattle manure.

14. ***The Composition of Indian Cattle Manure.***—In paragraph 121 of his Report on "The Improvement of Indian Agriculture," **Dr. Voelcker** compares the chemical composition of Indian cattle manure with that made in England, a comparison which showed that the Indian manure was quite as good as the European. At the same time **Dr. Voelcker** points out the desirability of extending the investigation, the evidence which he had at hand being limited to two analyses. I can now add some evidence on this point, having analysed a number of samples of manure made at the farms and also some produced by cultivators' cattle.

Dung of Grazing Cattle.

The accompanying statements exhibit the analyses of a number of samples. Considering, in the first place, the composition of dung of the cultivators' cattle, which is set out in Statement No. I, it will be seen that the percentage of Nitrogen and Phosphoric acid is much lower than that in the manure from the farms—*vide* Statement No. II. This manure was, however, from cattle which had nothing but very poor grazing to which a ration of straw or juar stalks was added. Work cattle, though not highly fed, are frequently supplied with a little additional food, such as oilcake, more particularly when doing heavy work, and whilst these analyses probably represent the composition of dung from grazing cattle, those in Statement No. II will more nearly represent that of the work cattle.

Dung of Work Cattle.

Statement No. I.—Composition of Dung of Grazing Cattle.

1893-94.

	407.	408.	409.	410.	411.	418.	434.
	Banthra.	Banthra.	Banthra.	Banthra.	Chiehat.	Bara Banki.	Kaswarpur.
Moisture . . .	76·05	75·62	77·18	78·27	78·84	75·61	73·95
Organic matter . .	14·90	...	...	14·46	13·43	14·69	15·95
Siliceous „ . .	7·24	7·88	7·98	6·92	6·67	8·46	8·24
P_2O_5	·182	·188	·173	·173	·167	·192	·126
N	·273	·217	·290	·207	·237	·269	·251

Statement No. II.—Composition of Cattle Manure at Experimental Farms.

	SIBPUR.	CAWNPUR.			NAGPUR.	DUMRAON.			BURDWAN.		
	1895.	Dung.	Litter and Urine.	Farmyard Manure.	Cattle Manure.	Cattle Dung.	Cattle Dung.	Cattle Dung.	Cattle Dung.	Cattle Dung.	Cattle Dung.
Moisture . .	65·48	46·60	25·38	33·86	62·77	32·85	71·59	25·96	59·19	72·23	67·84
Organic matter .	17·16	21·30	12·69	17·11	15·32	24·22	...	...	...	...	...
Siliceous „ .	12·27	24·56	52·39	40·98	16·80	31·28	12·85	41·45	22·30	11·38	12·85
P_2O_5 . . .	·597	·566	·290	·498	·755	·387	·299	...	...	...	...
N	·606	·811	·460	·652	·597	·656	·483	·847	·613	·464	·465

M. 237-59.

Generally, it may be said that the manure made at the farms is fully as good as that made in Europe. It is, however, frequently much drier.

Reason for conserving Cattle Dung.

15. ***The "Conservation" of Indian Cattle Manure.***—Of late years much more attention has been paid in England to the conservation of Farm manure. The researches of the late **Dr. Voelcker** showed that the valuable constituents of cattle manure, namely, the ammonia and other nitrogenous matters, the potash, the phosphoric acid, were largely in a soluble condition, and that if the manure were exposed to the weather, the rain would doubtless wash away more or less of these constituents, and they would thereby become lost to the land. On the other hand, it was shown that the loss by evaporation of the ammonia (or ammonium carbonate which is a volatile substance) was, under ordinary circumstances, probably but very slight. As an outcome of this, farmyard manure has been much more carefully kept; it is preserved in good square heaps and the drainage water is thrown back upon it from time to time; or what is a still greater improvement consists in the introduction of the "box" system. In India it may be said, without fear of contradiction, that one *rarely* sees any care at all bestowed by the cultivator on his farm manure heap. I do not refer here to that manure which is burnt, but to that which is in villages generally retained for application to the land. A common practice is to dedicate a hollow near the dwellings to the accumulated rubbish of the houses; another is to throw these materials on the banks of the village tank. In only two places have I found much attention given to the manure heap, the one is Gujerat, the other Dera Dun. In Gujerat especially is the general practice good. Many planters also pay great attention to the conservation of the cattle manure, and there may be other instances. The general rule is, however, as above stated. **Dr. Voelcker** in paragraph 148 of his Report cites examples of what he met with, and I may add a few of those which have come under my own observation. Around Banthra and Chinhat (Lucknow District) the manure heap is usually placed on the sides of the village tank, and in this case, it may be said, to be nearly all lost. Sometimes, as in a village near Lucknow, the heap finds a place on the side of the road. In other places, such as Satrikh (Bara Banki) a hole in the ground receives all refuse. This is indeed by far the most common practice; the hole is not a square, well made one, but a mere hollow, and the refuse is thrown into it.

Improved methods in England.

Neglect in India.

Examples.

This practice I have also observed in Bengal and in the Panjab. Generally in such a case the material is perfectly dry and the straw and twigs are not rotted at all. On the other hand, in Gujerat the manure is usually plastered down on the heap, which is gradually built up in a square well-kept hole, and one finds moisture close to the surface, and the dung well rotted; in the Dun the manure is carefully put in a hole and kept solidified, so that when brought on to the land it is quite rotten.

16. At some of the Experimental Farms the system adopted at present is to put the dung and litter into a hole over which a thatch is placed. It has been generally assumed that the important point is

Methods at the Farms.

Difficulty in keeping the Manure damp.

to keep off the rain during the monsoon. But so far the general experience has been that considerable difficulty exists in rotting the bedding material properly. The manure dries so dreadfully fast that there has frequently been far too little moisture in the heap and, instead of fermentation, molds form, accompanied by very great heat. It is common for a manure heap to be so hot about a foot below the surface that one cannot take hold of the material. At Nagpur it has been found desirable to throw some water on the heap in the hot weather, grass is also placed over the top and a thatch in addition, to keep off the *sun*, not the rain! With the pure cattle manure there is not much difficulty, but when bedding is also present, the heap is if anything too dry. It is probable that we have much to learn yet as to the best way of storing farm manure in India. The "box" system has been tried at Nagpur for some years, the amount of manure gradually rising to four feet in depth, and the same system is being tried also at Cawnpur. No evil results to the cattle have ensued so far, and if no other difficulties are met with, it will probably mean a considerable gain in the manure supply on the farms.

The "box" system in India.

At only two places in India have I found the cultivators' cattle kept standing on the manure. In the Bahraich District, around village Jarwal, and in the neighbourhood of Kinhauli, Bara Banki District, the cattle are kept under sheds with some bedding material, and 6 or 8 inches of manure gradually collects. The other instances is the method which is in vogue in some parts of Gujerat, The cattle are herded at night in a pen, which is set apart for the purpose, and the manure is allowed to collect on the ground until required. At the time I visited Gujerat in 1895 (March), the manure was naturally all dry and formed a layer about 4 to 6 inches thick.

II.—CATTLE BEDDING MATERIALS.

17. That it is an advantage to employ bedding under cattle in Europe needs no assertion here. The advantages of the system are well recognised and the practice is general. In India, on the contrary, cattle are generally tethered without any bedding at all, the exceptions to the rule which have come under my observation being the parts of Bara Banki and Bahraich to which I have referred in the previous paragraph, and the practice of tea and coffee planters. Dr. Voelcker in dealing with the question of bedding cattle so as to collect the urine (paragraphs 146 to 149 of his Report), refers to the argument used by cultivators that they have no straw for bedding, and proceeds to mention various refuse materials which are generally found in villages.

Bedding sometimes employed.

18. In England much more is spent on both food and bedding for cattle than in India, and doubtless the English farmer can afford to spend more than his Indian compeer. The value of farm animals generally is much greater in England, and the supply of straw, etc., *available* for bedding is also larger. It must not be supposed, however, that the English farmer has unlimited supplies of straw. On the

English practice.

contrary, both peat and saw dust are being used for stables and cattle byres which shows that the home farmer has to pay a price for his bedding material.

Straw of Indian crops mostly required for other purposes.

19. Judging by enquiries I have made when on tour, it would seem that the refuse of various crops, that is, the parts which are not used for human consumption or in the arts is mostly put to certain uses and is really required. The straws are largely fed to cattle and form indeed the main part of their food supply. Rice straw is employed largely in thatching. The small stems, leaves and husks of the pulses are also fed to cattle; thick stems, *e.g.*, those of *arhar* and the castor-oil plant are used in thatching; those of indigo are largely put on the land for manure (which is their proper destination) though sometimes it is used as fuel; the "megass" of sugar-cane is required for fuel, the green leaves of sugar-cane are fed to cattle, the *dry leaves* are largely burnt on the field. The dry leaves of trees are used largely for grain parching. Thus taken as a whole, it would seem that the major portion of the stems and leaves of the crops are put to other uses, and one cannot say that the practice is bad in general.

Sugar-cane leaves available.

20. Indeed the only point in the system which appears to me to be faulty is the burning of the dry leaves of sugar-cane, which is done in the field after the crop has been removed and is certainly wasteful. So far as this material is concerned, I may say that it forms an excellent bedding material, it is the only one employed at the Cawnpur Farm. Nor can it be said that this is a very small item. In the North-Western Provinces there are 1,000,000 acres of sugar-cane, the weight of dry leaves will not be less than 700lb per acre which would be a very liberal supply for two beasts for a year; thus the sugar-cane of the Province would, taken as a whole, supply bedding for 2,000,000 or about one-third of the work cattle. Of course sugar-cane is not uniformly cultivated even in the one province—in some parts it is less cultivated than in others, so that it would not be true to say that one out of every three of the work cattle of every village might be bedded with the dry sugar-cane leaves of the village; but sugar-cane is so very generally cultivated in villages throughout India, that it must be allowed this material does by itself really form a very large and general supply. But apart from this and allowing that there is a scarcity of bedding material, the Scotch proverb, "Many a mickle makes a muckle" might be appropriately quoted as indicating how more bedding might be found. Any one who has watched cattle feeding on such things as juar stalks and even straw in the villages, must have observed that there is always some wastage. There are also the leaves and other dry vegetable debris of every village, and certainly some of this would serve the purpose under consideration. It is in this manner that the bedding supply of the country might be augmented. If the people practised economy in this respect as they do in many other directions, a very great increase in the manure supply would be the immediate result. I have come to the same conclusion as Dr. Voelcker in this matter, namely, that the

people do *not* in many parts know how to preserve cattle manure properly; it is a matter which can only be explained to them gradually, and, as agricultural education spreads, we may anticipate an improvement in the practice of this chapter of agricultural economics.

Loose earth as a substitute.

21. There is possibly another means of securing cattle urine, instead of employing bedding, and that is by spreading loose earth in the stalls. Dr. Voelcker in paragraph 146 of his Report mentions this, and it is certainly a means which deserves trial. An experiment is now being conducted at the Cawnpur Farm with it, but the experience gained is too short to admit of an opinion being formed. The principle is perfectly sound. It is based on the fact well known that earth forms an excellent absorbent of various soluble matters. It will absorb, *i.e.*, take up such things as potash and ammonia salts, and organic matters from their solution in water, and the drainage water passing away will be found to be poorer in them than before. Moreover, in actual practice the amount of earth required to wholly absorb urine and thus to allow no drainage whatever is not great, and if it be dried, as it may readily be, throughout the greater part of the year, in a few hours, the same earth may be again employed and again dried. How long the process might be repeated on the same quantity of earth is a question which experiments alone can decide. Other questions may doubtless occur in practice, but it is probably a practical way of securing the greater part of the urine deposited in the villages.

22. One set of analyses which I made to test a point in relation to this subject may here be detailed.

In paragraph 16 I have explained that in Gujerat the village cattle are penned in an enclosure, and that the manure is allowed to collect. I took three samples of the earth below the manure, the first being the top soil 1″—6″, the second, the next soil underneath, 6″—1′ 6″, and the third from the depth 1′ 6″—2′ 6″. The proportion of Nitrogen was determined in each in order to see how far the soluble Nitrogen compounds had descended; a sample of the surface soil from the neighbouring (rice) land was analysed to indicate the amount of Nitrogen in the soil generally. The soil was of the type known as "black cotton," and as this is one of the most "open" soils known, one would expect the salts to pass lower down than in such a soil as that of the alluvial areas. Statement No. III contains the figures.

Statement No. III.

1″—6″	6″—1′ 6″	1′ 6″—2′ 6″	Rice land. 1′—6″
% Nitrogen.	% Nitrogen.	% Nitrogen.	% Nitrogen.
·152	·045	·034	·068

It will be seen that the amount of Nitrogen in the soil at 6" deep (·045) is rather less than in the rice land soil, and since the proportion of Nitrogen in the soil at 1' 6" is very little different from that at 6", it may be assumed that none of the ammonia salts had passed lower, if as low down as 6"; *i.e.*, the first few inches of soil had retained the valuable salts of the urine entirely. The analysis of one sample of cattle urine from the Cawnpur Farm may here be quoted.

Water.	Organic matter.	Mineral matter.	Nitrogen.
91·84	2·57	5·59	·87

III.—NIGHT-SOIL AND TOWN REFUSE.

23. That the night-soil and other refuse of town and villages is of great value as a manurial agent requires no assertion here. It is a fact well known to all. Further, that a great part of the materials thus included go directly on to the land is also well known. The customs of the people inhabiting "hamlets" and the outskirts of towns and large villages secure material economy in this matter. On the other hand, there is a large part which is not brought directly on the land, but has to be carried from the houses. In large towns various systems are in vogue for dealing with this; in villages the need of a system is patent to all who pass through their bye-paths.

Some goes directly on the land.

Some requires removing.

24. Regarding the proper disposal of these matters in the case of large towns, there are several methods in use and three of them have been dealt with in *The Agricultural Ledger No. 16 of 1895* (Agricultural Series, No. 15) and do not require more than a mention here. They are the "poudrette," the "deep trench" and the "shallow trench" systems and are employed for the disposal of human fœces.

Modes of dealing with night-soil.

25. The composition of poudrette will vary very considerably according to whether it be dry or damp, or whether much or little ashes are employed in its manufacture. The poudrette employed for the Poona sugar-cane experiments has usually contained from 15 to 25 per cent. of moisture, and from ·9 to 1·1 per cent. of Nitrogen. The Cawnpur poudrette has generally contained more earth and less moisture (only about 3 to 6 per cent of water); the proportion of Nitrogen has varied from ·4 to ·7 per cent. The proportion of Phosphoric acid varies very much more and depends probably on whether ashes are largely employed in its preparation; one sample from Poona contained only ·2 per cent., whilst another contained 1·5 per cent.

Composition of poudrette.

26. Regarding its value as a manure the following experiments may be quoted. At Cawnpur it has been applied for 14 years to maize (two plots) and to wheat (two plots). The following Statements Nos. IV and V contain the results—expressed in pounds per acre.

Value of poudrette.

Statement No. IV.—Showing the mean outturn of Maize per acre at Cawnpur.

Maize.	Mean of three years, 1884-87.	* Mean of three years, 1889-92.	Mean of three years, 1892-95.
	lb grain.	lb grain.	lb grain.
"Standard" Series—180 mds. Poudrette (6·6 tons)	974	1,319	1,146
"Duplicate" Series—180 mds. Poudrette (6·6 tons)	1,249	1,472	1,535
"Standard" Series—180 mds. Cow Dung (6·6 tons)	1,031	1,145	1,014
"Duplicate" Series—180 mds. Cow Dung (6·6 tons)	950	963	800
"Standard" Series—No Manure . .	606	564	686
"Duplicate" Series—No Manure . .	321	581	470

Statement No. V.—Showing the mean outturn of Wheat per acre at Cawnpur.

Wheat.	Mean of four years, 1884-88.	Mean of four years, 1888-92.	Mean of three years, 1892-95.
	lb grain.	lb grain.	lb grain.
"Standard" Series—180 mds. Poudrette (6·6 tons)	1,208	1,512	1,701
"Duplicate" Series—180 mds. Poudrette (6·6 tons)	1,641	1,709	1,850
"Standard" Series—180 mds. Cow Dung (6·6 tons)	1,237	1,358	1,742
"Duplicate" Series—180 mds. Cow Dung (6·6 tons)	1,495	1,800	1,417
"Standard" Series—No Manure . .	889	1,101	1,033
"Duplicate" Series—No Manure . .	1,077	1,261	1,140

* *Note.*—The maize crops were an entire failure in the years 1888 and 1889.

In several years the maize crop has failed on account of excessive rain. The Statement No. IV exhibits the means of three periods of three years each. The outturn obtained with Cattle Dung is also inserted for comparison. In the two "Standard" Series maize and wheat respectively is grown every year, whilst in the "Duplicate" Series maize and wheat alternate with one another. There are two "Duplicate" Series of plots on which wheat and maize are grown in alternate years, so that a maize crop is obtained from either the one or the other "Duplicate" Series of plots each year. Although the results are not quite uniform, it is clear that a larger outturn of maize has been obtained from 180 maunds of poudrette than from a like weight of Cattle Dung.

In the case of wheat, the outturns of which crop are detailed in Statement No. V, the 180 maunds of poudrette has not produced much more wheat than the same weight of Cattle Dung.

At Poona, in the case of the sugar-cane grown in 1894-95 and 1895-96, there has been obtained in both years a *much* larger amount of sugar from the plot manured with poudrette than from the one to which an equivalent amount of cattle manure was applied. Thus, these experiments indicate not only the increase of produce due to poudrette, but show that the poudrette has, in the case of maize and sugar-cane, produced more than a similar weight of cattle manure.

27. One important point must also be referred to. It may be advisedly asked whether the *same weight* of poudrette and cattle manure really means approximately an application of like amounts of plant foods, *e.g.*, Nitrogen, Phosphoric acid, etc. It is only during the last year or so that any analyses of the manures employed at the farms have been made, and consequently we know nothing of the composition of the poudrette and cattle manure which was applied at Cawnpur during the years to which the statements refer. But if they have been generally of the same quality as that employed recently, both these manures will have contained much about the same amounts of Nitrogen. The amount of Phosphoric acid has probably varied a good deal, but since the experiments generally at all the farms indicate that Nitrogen is the principal controlling factor for (at least) cereals, millets and sugar-cane, it may be assumed that the manures have really been applied in equivalent quantities. At Poona the manures were analysed each year and approximately equal quantities of Nitrogen applied.

Amount of Night-soil available.

Some information relative to the amount of night-soil available which I have received from Meerut and Nagpur will be of interest. A part of the night-soil and sweepings of Nagpur is brought to the farm, and there converted into poudrette for the colony of Kachis which were imported in 1882 by Mr. Fuller from the North-Western Provinces. About 400 cubic feet of night-soil and 140 cubic feet of sweepings are obtained *daily* from a part of Nagpur, the population of which is 24,000. The above quantity is sufficient to fill one pit and forms about 218 cubic feet of poudrette (a considerable quantity of liquid apparently drains through the bottom). When this poudrette is considered fit to put upon the land, it weighs about 6,260lb; the loss due to drainage and drying being apparently equal to more than 70 per cent. The poudrette manures 23·75 acres, and

the average amount of poudrette applied per acre is thus equal to (6,261 × 365 ÷ 23·75) = 96,220lb or some 43 tons. This, it may be mentioned, is similar to the amount of poudrette which the cultivators around Poona employ for sugar-cane. At Meerut the Municipality removes about 210 maunds of night-soil daily from the city, the population of which is about 73,000. This is *trenched* and not made into poudrette, and manures 16 *kucha* bighas, or only about 3 acres annually. If it were converted into poudrette, and assuming that 75 per cent. is lost as at Nagpur, it would form some 4,000lb of poudrette daily, or more than 600 tons annually. It is, however, applied direct to the land and the losses due to drainage cannot approach those obtaining at Nagpur; the manure must be assumed to be equivalent to much more than 600 tons annually, and thus *the rate is probably equal to more than 200 tons per acre!*

The sweepings of the Meerut streets are partly used for brick-burning and partly put into pits, which are sold later. Each pit receives the contents of 60 carts; 1 cart contains 30 maunds; this quantity (1,800 maunds) is commonly applied to 4 bighas *kucha* or, say, $\frac{4}{5}$ acre, which is equivalent to about 80 tons per acre. Sweepings are not generally nearly so concentrated a manure as poudrette; assuming them to be half as valuable, this rate becomes about equivalent to that which the Nagpur Kachis apply. At Allahabad, where the shallow trench is employed, 70 gallons of night-soil is applied to 9 square yards which is equal to [(700 × 4,840) ÷ (9 × 2,240)] about 168 tons per acre; but the land is only manured once in 10 years. 130 to 140 carts (70 gallons each) of night-soil and 70 carts (1 ton each) of sweepings are here applied daily, and manure about 200 acres of grass land annually, and since one manuring is assumed to be sufficient for 10 years, the total area manured is assumed to be 2,000 acres. Although this land only produced grass, the produce per acre is very high. For instance, the following outturns are published in Statement C (page 14) of the Report for 1892-93:—782 maunds per acre, land manured 5 years previously; 257 maunds from lands manured 7 and 11 years previously; 850 maunds from land manured 5 years previously; 277 maunds from land manured during preceding 4 years; 378 maunds from manured land. Thus from 10 to 30 tons of green grass (equal to 3 to 10 tons of hay) is removed per acre, and is equal in its requirements on the soil, to the heaviest agricultural crops grown. The foregoing illustrate the comparative areas on which night-soil and sweepings are applied. The Allahabad rate, though high in the first instance, is much the lowest in reality, being, in the case of the night-soil, about 17 tons per acre per annum. The rate of about 43 tons of poudrette per acre per annum at Nagpur and that of 80 tons of sweepings at Meerut are certainly high; but when the weight of night-soil applied per acre at Meerut is considered, it must be admitted as being altogether far too high for any land. It is not improbable that the same manure might be put on five times the area and still yield as good crops.

Sweepings.

28. From towns there is also that refuse which may be designated "Sweepings," and which includes all the various materials which are swept from the streets. Considered in comparison with many other

manures, this material, although it will vary considerably, is not a very rich manure. A sample from Poona contained ·4 per cent. Nitrogen and one from Dumraon ·3 per cent. Nitrogen. Its quantity, however, is very large, and, provided it can be utilised near a town, it becomes a very valuable item. If its proportion of Nitrogen be low, it, on the other hand, contains in addition a considerable amount of organic debris and ashes, materials which assist in opening up the soil. As examples of how it is disposed of the following may be quoted.

At Allahabad it is bought for the grass land of the Commissariat Farm where it is applied in two ways: (1) it is simply spread on the grass land; (2) it is put into trenches, 1 foot deep and 6 feet broad; the latter is naturally far more expensive than the former, but a much greater quantity is applied per acre and the effect will be correspondingly more lasting; where the land has become very hard through long periods of grazing this method will probably pay.

At Meerut the material is stored in pits and later sold to cultivators. At Nagpur it is utilised in the poudrette pits. On the other hand, very large amounts of sweepings are annually consumed in brick-kilns; at Meerut, Cawnpur, Dumraon, Nagpur it is thus used.

Some part used in brick kilns.

29. In addition to the night-soil and "sweepings" there is another refuse material obtainable from towns, namely, the "Sullage" or Drainage Water. This is, I believe, not generally brought upon the land, but is allowed to run into the nearest river. Its value will doubtless vary according to the amount of water passing down the drains, but at Meerut, where it has recently been used on the demonstration farm, two irrigations with it caused about one hundred per cent. increase in the case of cotton, maize, juar and oats, the four crops experimented with. The outcome of these experiments was that cultivators commenced forthwith to set up "Dhenklis" for raising the water on to the fields. There is probably room for a very large extension of the practice.

Sullage Water.

30. Another source of town manure which, though limited, is fully worth mention, is a portion of that produced in jails. Generally it may be said that nowhere is more economy shown in the utilisation of manure than in the case of jails. The night-soil and urine as well as whatever cattle manure is produced, is brought on to the jail garden and very heavy crops of vegetables grown.

Jail Urine.

This first case which I had an opportunity of examining was the Presidency Jail Garden, Calcutta, and I obtained through Mr. Donaldson, the Superintendent, some figures relative to the amounts of manure there used. Besides some 2,400 maunds of food stuffs grown in the garden, there was imported 2,700 maunds of pulses and 840 maunds of straw, and the whole of the manure was regularly trenched in the garden. This meant practically a very large importation of "manure" indeed; not less than 10 times as much of both Nitrogen and Phosphoric acid as there was in the vegetables grown. Of course for gardens it always pays to manure heavily, but it is probable that in such a case as the one quoted the manure might have been employed more advantageously on a much larger area.

Meerut experiments.

At Meerut recently Mr. Wyer, the Collector, has been experimenting with the utilisation of jail urine. It has been found that the jail garden can do without the urine, and it is simply thrown into pits which are afterwards filled up. It is, in the undiluted state, liable to "burn up" crops, and for this reason as well as the difficulty experienced in carrying it, it is not taken by the cultivators. Mr. Wyer has, therefore, commenced to try the experiment of absorbing it with dry earth. It has been found that a maund of earth will absorb (*if added gradually*) two maunds of urine, and since this becomes a dry material which can be carried in an ordinary cart, it should prove a very practical way of disposing of it. It would seem probable that there is a certain proportion of the manure produced in jails which would become available to the cultivator.

Some part lost.

31. ***Village Night-soil.***—Although in villages much of the night-soil goes directly on to the land, there is frequently no small quantity which does not. For example, one generally sees a dark coloured, most objectionable liquid oozing through a small hole from the houses into the road or into a small excavation at the base of the wall. This may be sometimes periodically removed to the fields, but in other cases it certainly accumulates, or rather runs away and never reaches the land at all. It is not the object of this paper to touch upon village sanitation, but I may mention a case which came under my observation and which seemed to be distinct improvement on the general run of things.

At Kaisarganj in the Bahraich District there is a fairly well-kept hole behind each house into which not only sullage water, but also all sweepings, etc., are stored. In such a case the dry materials absorb the sullage water, and the whole may be readily brought upon the land.

Rise in price of poudrette.

32. Although it is thus apparent that a great deal of useful manure is being regularly brought upon the land from towns, there is still, I am convinced room for considerable development of improved practice and corresponding gain both to the towns from the sanitary point of view, as also to the cultivator. Apart from the cost of collection, etc., a difficulty doubtless also lies in the cost of carriage. The manure might, I feel sure, be economically employed over a larger area if, instead of the poudrette system, something like the Allahabad "shallow" trench could be adopted. A hopeful sign is the fact that both at Poona and at Cawnpur the price of poudrette has been rising very considerably of late. At Poona the best poudrette sells at R4 per cart load and at Cawnpur the price has risen from annas 4 to R1 per load. It is perhaps rash to speculate too far, but if it pays to carry fire-wood at Changa Manga on a "light" tramway, it is quite possible that it would pay Municipalities to transport night-soil by the same means.

Night-soils might become a source of *profit* to Municipalities.

There is generally little or no "push" exhibited by Municipal bodies in relation to the disposal of city refuse. If it were looked at more as a source of income than one of nuisance, much more might frequently be made out of it. At Meerut, for example, it has become in a few years from a debit charge of some R10,000 to an actual source of profit. An establishment, such as the little demonstration

farm at Meerut, may readily become (as in the instances quoted) a means of exhibiting the value of these manures to the people, and thus also an indirect road to enhancing Municipal revenues.

IV.—OILSEED CAKES.

33. In paragraph 127 of Dr. Voelcker's Report, attention is directed to the question of the export of oilseed and oilseed refuse. As is well known the oil of a seed has no manurial value, the oilseed refuse, on the other hand, has a very considerable one, and Dr. Voelcker urges that it is not good agricultural economy to send this material away—that rather the oil should be expressed from the seed in India and it alone exported. The "oil cake" obtained should then be either fed to cattle or be applied to the land direct as a manure. That oilseed cakes have, with one or two exceptions, both a high feeding and a high manurial value there is no doubt. It is a fact well recognised in Europe generally and large imports of these materials are made from both America and India. Before going into particulars we may say that the exports from India are steadily increasing in all respects, *viz.*, in oil, in oilseeds and in oil-cake, but more especially in the case of the two last named. The important question is naturally, "What is this export really equivalent to so far as India in concerned?" Admittedly in a country where manure of all kinds is scarce, compared with the supply in some of the leading European countries, any deliberate export of materials useful as manure, is a mistake from the economic point of view. The trade, however, exists; a price is offered to the Indian cultivator for these materials and he accepts it. But since they are bought by agriculturists of other countries for precisely the same uses as those to which the Indian cultivator *might* put them, it seems clear that an economic blunder is being committed. It is true that they are not only imported into Europe as manures, but, also, and this primarily, as cattle foods. In India they *should* be also employed in the same manner, for both the work cattle and land in India are even more hungry than are the fattening stock and the land of Europe. It becomes indeed a question as to who will pay the higher price for them—the European or the Indian agriculturist. It is quite clear from the fact that the export trade in oilseeds and oil-cakes is on the increase, that *at present* the European values these materials at a higher rate than the native of India; their price will only be increased in India as the people become more aware of their feeding and manurial value.

Increased exports.

Oil-cake as valuable to the Indian ryot as to the European farmer.

It is a case where demonstration can play a useful part, and as Dr. Voelcker has pointed out in the paragraph referred to, this should be taken up by Agricultural Departments.

Demonstration may do good.

34. Since the object of this paper is to show what the value of various oilseed cakes is as *manures*, their value as foods will not be discussed; the fact that they form in many cases very valuable fodders must nevertheless be kept in mind. The principal oilseeds of India are Linseed, Rape and Mustard, Sesamum, Cotton, Earthnut, Safflower, Cocoanut, Castor, *Mahuá* (Bassia latifolia), Pongamia

Principal oilseeds.

glabra and Poppy; the first seven are edible, the last four are not so.

35. ***Linseed.***—There are over four million acres of linseed grown annually in India to which must be added 3¾ million acres on which it forms a part of a mixture of crops. The pure crop is grown principally in the Central Provinces, Berar, North-Western Provinces and Bengal; the mixed crop is grown principally in the North-Western Provinces. The total average outturn is estimated to be about 647,000 tons. The seed is largely exported *as such*. In 1888-89 420,000 tons were exported, in 1894-95 the corresponding figure was 450,000 tons. In addition to this, 95,000 gallons of linseed oil were exported which is equivalent to about 1,200 tons of seed. From this it appears that nearly ¾ of the seed produced is exported as such, leaving about ¼ for consumption in India. No details of the exports of linseed cake are available. Linseed cake has not, so far as the writer is aware, been employed direct to the land as a manure in India. Its value as a food is so great that its price in Europe prohibits it being used as manure. It contains from 4 to 5½ per cent. of Nitrogen.

36. ***Rape and Mustard Seed.***—About 14,700,000 acres bear different varieties of rape and mustard seed, of which some 9,700,000 acres bear other crops at the same time, rape or mustard forming one item of the mixture. The estimated average outturn is 1,221,000 tons of seed. Of this, 237,000 tons of seed were exported in 1894-95. In 1888-89 the corresponding figure was 150,000 tons, thus showing a considerably increased export. In addition 175,000 gallons of oil were exported in 1894-95 which is equivalent to about 2,100 tons of seed. Thus much the greater part of the seed produced is consumed in India; it is pressed and the oil-cake is regularly fed to cattle. Regarding the manurial value of the cake, no experiments have been made in India, but it has been employed for this purpose for many years at Rathamsted in England, and there 1,000lb of rape cake have produced a rather larger outturn of barley than 14 tons of farmyard manure. It usually contains, when pure, about 5 per cent. of Nitrogen, but there is frequently less than this on account of an admixture of sand and earthy matter.

37. **Sesamum indicum,** ***Til or Gingelly.***—The average area under this crop amounts to 1,900,000 acres, the greater part of this area lying within the southern half of the Empire. The average outturn is estimated at 176,000 tons. Of this the export as seed was 116,000 tons in 1894-95. The corresponding figure in 1888-89 was 77,000 tons, the export of this seed having increased very considerably. In addition 325,000 gallons of the oil, equivalent to about 4,000 tons seed, was exported in 1894-95. Thus it is seen that about ⅔ of the total seed is exported as such, leaving ⅓ for consumption in India. The cake forms a valuable cattle food and is fed to cattle in India. Regarding the manurial value of the cake no information is available. One sample analysed, contained 5·4 per cent. of Nitrogen.

38. ***Cotton Seed.***—The average area under cotton in India is about 14,500,000 acres, and the average outturn of cotton is estimated to be 2,777,000 bales of 400lb each. From the weights of seed and lint obtained at Nagpur and Cawnpur, the weight of the seeds may be assumed to be twice that of the lint, and the weight of seed produced in India may thus be calculated to be about 992,000 tons. The export is very trivial; in 1894-95 it was 4,800 tons. Thus it is certain that nearly the whole remains in India. It is a valuable cattle food, and doubtless it is mainly consumed in this manner, though it is also probable that a very large amount is consumed by the milch cows and buffaloes in the towns. Regarding the value of cotton-seed cake as a manure, it has been employed for the sugar-cane crop at Poona last year, when it proved itself equal to certain other oilseed cakes and to poudrette applied (as they were) in proportion to their content of Nitrogen. It contains from 3-4 per cent. of Nitrogen.

39. ***Earthnut.***—There is no definite information as to the area under earthnut. The crop is largely cultivated in Bombay (159,226 acres in 1894-95), Madras (226,147 acres in 1894-95) and in Mysore. The crop experiments, which have been made in the Bombay Presidency, show that it is a heavy yielder, and although the information is limited to some half a dozen weighments, 1 ton of seed per acre will not be an extravagant figure to adopt. The area above quoted (385,373 acres in Bombay and Madras) would thus account for some 385,000 tons, but the total outturn must be much larger. The export of 1894-95 was 113,000 tons of seed; that of oil 18,000 gallons equivalent to about 200 tons of seed. The total outturn is not unlikely fully 500,000 tons, and the export would thus come to about $\frac{1}{4}$ of the whole production. The seed is largely consumed as human food. It also forms an excellent cattle food and is crushed both by itself or with safflower seed. Regarding its manurial value we have indirect evidence obtained from the use of "safflower and earthnut" cake in the Poona sugar-cane experiments in 1895-96, when it proved to be a very good manure. One sample of earthnut cake contained 7·4 per cent. of Nitrogen.

40. ***Safflower Seed*** **(Carthamus tinctorius).**—Regarding the safflower crop and the total outturn obtained there is very little information. In Bombay 571,804 acres were under the crop in 1894-95, but no returns are available for other provinces. Nor is there any estimate of its export. The seed is crushed for its oil in Bombay and Madras Presidencies, and the oil-cake is a most valuable cattle food. The cake was employed as a manure for sugar-cane at Poona in 1895-96 where it produced a very heavy crop. It contains 6-7 per cent. of Nitrogen.

41. ***Cocoanut Cake.***—Although this does not belong to the class "Oilseeds" in the general acceptation of the term, mention of it must not be excluded here, since the cocoanut is a fruit which produces both an oil and a very valuable oil-cake which is largely fed to cattle both in India and in Europe. No information is

available as to the supply of this material, nor is its value as a manure known. It contains about 3 per cent. of Nitrogen.

42. ***Castor-seed Cake.***—The area under castor-seed cake is only known for Madras and Bombay Presidencies; 728,047 acres and 114,940 acres, respectively, were under the crop in these two Presidencies in 1894-95. In Bombay the outturn has been found to vary from 180 to over 400lb of seed per acre; the average outturn in Madras is stated to be 473lb per acre (Watt's Dictionary). Since the plant is cultivated extensively all over India, the total area under the crop can hardly be less than 1,500,000 acres, and if 300lb per acre be considered an average outturn, the total would amount to some 200,000 tons, and this is probably a low estimate. Of this 58,000 tons was exported as seed in 1894-95; in addition 2,679,000 gallons of castor oil, equivalent to some 34,000 tons of seed, was exported. The oil-cake is not edible, but it forms an excellent manure, and this is well known to cultivators in all parts of India. For instance at Poona and in Gujerat it is applied to sugar-cane, at Burdwan it is employed for potatoes. The price too has risen very considerably of late years; for instance, at Cawnpur it could be bought for Rs-14-0 per maund 10 years ago, its price now being R1-8 and at Poona its price is R2 per maund now. In some parts there is a prejudice against it; for example, in the Lucknow District I found that the people would not use it for the pan vine (**Piper Betle**) although they applied the rape-seed cake; they objected to the castor cake as being "unclean." This is, however, merely an example of ignorant prejudice in a very backward part; the castor cake is increasing in value all over India. In fact it is actually cheaper at present to buy some of the edible cakes for manure than to buy castor cake. It is indeed partly for this reason that at Poona three different edible cakes are being applied as manures for sugar-cane. But the quality of castor cake varies to a much greater extent than is the case with most oil-cakes. Seeds, as a rule, are very uniform in composition, and when oilseeds are crushed, it is found that the proportion of Nitrogen which they contain does not vary very greatly. In the case of seven samples of castor cake obtained from Poona, the per cent. of Nitrogen varied from 3·12 to 4·13, whilst of six samples obtained from Cawnpur, Burdwan and Dumraon, the lowest contained 6·11 per cent. Nitrogen, the highest 8·0 per cent.; thus if these thirteen samples really represent the general quality of the cake in the respective places named, one may say that that produced on the east side of India contained just twice as much Nitrogen as that produced on the Bombay side. It is a curious case which deserves further investigation. At some of the farms castor cake has been employed as a manure for certain crops. At Poona the results of 2 years' experiments show it to be equal to poudrette, reckoned in the ratio of the Nitrogen content. At Burdwan it has been compared with cattle manure for rice and jute for several years, 6 maunds of castor cake have produced nearly as heavy a rice crop as 150 maunds of cattle-manure, the amount of Nitrogen in the castor cake

applied being probably very much less than in the dung; in the experiment with jute the outturn from the plot manured with cattle manure has been generally in excess of that from the plot to which castor cake is applied, but since the amount of plant food supplied in the castor cake was probably much less than in the cattle manure, the comparison is hardly as simple a one as might be wished.

43. ***Mahua-seed Cake*** **(Basslia latifoia)** ***and Karanji Cake*** **(Pongamia glabra).**—The seeds of both these trees are crushed and the refuse cakes form probably valuable manures. The *Mahuá* cake contains (as judged by two samples from Poona) about 2·5 per cent. of Nitrogen; the *Karanji* cake (of which four samples have been analysed) contains from 3·5 to 4·0 per cent. of Nitrogen. They are not, I believe, extensively employed as manures. At Poona they are being employed for this purpose in the sugar-cane experiments, and they have so far done very well, but the data are too few to rely on at present.

44. ***"Posta".***—Under this name the refuse poppy-seed "heads" is known in the Cawnpur District. One sample which I have analysed contained ·77 per cent. of Nitrogen.

45. The foregoing gives an idea of the amount of oilseed and oilseed cake available in India, the amount exported as seed and in some cases the relative manurial value of the oil-cake.

Regarding the export of oil-*cake*, the returns do not particularise between different sorts, but merely give the total of all sorts exported. This was in 1889-90, 14,800 tons; in 1894-95, 23,000 tons. It is therefore, an increasing amount. At the same time the main question is, what proportion of the whole supply is being exported? In the subjoined Statement No. VI. are set out the outturn, the amount exported as seed, the amount of seed which is equivalent to the oil which is exported, and the total export of oil-cake, for those oilseeds for which estimates can be formed. Proportion exported.

Statement No. VI.

	Production.	Seed exported as such.	Seed equivalent to oil exported.	Oil-cake exported, 1894-95.
	Tons.	Tons.	Tons.	Tons.
Linseed	647,000	450,000	1,200	
Rape and Mustard . .	1,221,000	237,000	2,100	
Sesamum	176,000	116,000	4,000	
Cotton	992,000	4,800	...	
Earthnut	385,000	113,000	200	
	3,421,000	920,800	7,500	23,000

Of the total oilseeds contained in the above list, about one-third is exported. But of safflower, earthnut, castor, *mahuá*, *karanji* and cocoa-nut, the supplies of which are undoubtedly very considerable, no statistics exist which would show how much is exported and how much retained. It is very probable, however, that the proportion of these exported is very much less than in the case of those enumerated in the statement, and consequently the proportion of the oilseeds exported must be considerably less than one-third of that produced. The amount is nevertheless very large indeed and if the oil-cake could be retained it would mean a very considerable supply of food and manure which might be converted into an increase of food grains.

Uses of oil-cakes.

46. It may be urged that since some of these oil-cakes are utilised by the people as cattle food, it is a mistake to demonstrate to them their value as manures, thus inducing them in a measure to take from their cattle a part of the little extra concentrated food which they at present enjoy. There are generally two sides to a question, and the present one forms no exception to the rule. **Mr. Mollison** puts his view of the matter in the following terms (paragraph 15, page 30 of the Poona Farm Report for 1894-95). **Mr. Mollison's view.** "There are several edible oil-cakes now used for feeding cattle in India and largely exported, which can be bought in Poona at a considerably cheaper rate per ton than the castor cake and *karanji* (**Pongamia glabra**) cake now so extensively employed as manure **Dr. Leather's** analysis proves that the edible cakes contain much higher percentages of Nitrogen (the most valuable constituent of manures) than the manure cakes, and in our extended scheme of comparative manure experiments started in the current season, the value of the edible cakes as manure is being tested. I had no hesitation in proposing this trial, because these edible oil-cakes are either exported and thus lost to the country or they are chiefly fed to milch cattle in large towns. The solid and liquid excrement of these cattle is not used as manure. The urine drains away somehow, whilst the dung is sold (in Bombay, for instance, at 8 annas a cart load) to be converted into cow-dung cakes and burnt as fuel."

47. This may prove one way of saving the oilseed cake for India. On the other hand, there can be no doubt that the true economy is to feed the edible ones to cattle and to apply the dung to the land. In this case, in addition to the albuminoids, the carbohydrates, which form the greater part of them would help by sustaining the vitality of the work cattle and the greater part, probably 90 per cent. of the Nitrogen would still go back to the land. As already pointed out, this is the economy which is practised in Europe, and it is for these two purposes that the European farmer buys these cakes, and he will probably be able to offer a higher price for them so long as the same value is not put upon them by the Indian farmer. We may be a long way from the time when this creed can be effectively taught to the Indian cultivator, but it is the one which should be professed by lecturers on agriculture, and the seed thus sown may some day bear fruit.

V.—BONES.

48. Owing to the value which bones, both in the simple ground-up condition as also in that of "Superphosphate" or "Dissolved Bone," have been found to possess in Europe for certain crops, principally Turnips and Mangel Wurzels, it has been assumed that they are of equal value to the Indian cultivator, and much has been said against their export. Unquestionably the export is large; it is probably even a large proportion of the bones annually available. The exports have, moreover, increased steadily from 18,000 tons in 1884-85 to 76,000 tons in 1894-95. The main question, however, so far as agriculture is concerned, is, what are bones worth as a manure? If they produce little or no increment to the crops of the Indian ryot, it must be admitted that there is no such want of agricultural economy as has been urged so frequently. Now fresh bones may be said to consist principally of phosphate of lime and nitrogenous substance (gelatine), they will usually contain approximately 45 to 50 per cent. of phosphate of lime and 3 to 4 per cent. of Nitrogen. It is clear, therefore, that their principal constituent is Phosphoric acid. They have been found in England to exert, when applied in moderate quantities of a few cwts. per acre, a very considerable influence on the root crops and grass lands, whilst on cereals they have exerted a much smaller influence when applied in the above indicated quantity. Of course if they be applied in larger amount, so as to supply a reasonable amount of Nitrogen, it might be expected that cereals would be benefited by them more or less.

Use of bones in Europe.

Exports.

Composition of bones.

Quantity applied as manure.

49. It is important to bear this question of quantity in mind, because one might legitimately ask, if it pays to apply oil-cakes as manures, some of which only contain about 4 per cent. Nitrogen or less, why should not bones be also applied for the sake of their Nitrogen. As a matter of fact, this question was considered when the present sugar-cane experiments were about to be instituted at Poona in 1894. Bones could then be obtained for ₹24 per ton, and debiting the whole cost to the Nitrogen in them, it was one of the cheapest forms of nitrogenous manure then available, and they were accordingly applied as a *nitrogenous* manure. During the following twelve months, however, the price of bones near Poona became more than double, and they could no longer be considered a cheap "nitrogenous" manure. Their market value is due to the phosphate they contain, and they can only be recommended to the Indian ryot if they are found to possess a special value for certain crops in the same way as they are found to exert a special value in England for the root or grass crops.

Increase in price.

50. A number of experiments have been made at the different farms, and it will be well to consider these in some detail.

Experiments made in India.

Rice and *kesari* (**Lathyrus sativus**) have been grown on six plots at the Dumraon Farm; three of the plots have been manured with 6 maunds (492lb) of bone meal before sowing. Statement No. VII. shows the weight of the crops, the upper part giving the outturn of paddy,

Dumraon.

the lower division that of *kesari*. With one or two exceptions, the outturns are practically the same on the unmanured as on the manured plots. The plots alternate with one another, so that the negative result from the bone manure cannot be referred to inequality of the soil.

Statement No. VII.—Showing the outturn per acre of Paddy, Grain and Straw in the experiment with bone manure.

DUMRAON.

No. of Plots.	Area in square yards.	Special treatment.	1893-94. Grain.	1893-94. Straw.	1894-95. Grain.	1894-95. Straw.
			lb	lb	lb	lb
13	800	Bone manure at 6 maunds per acre.	806	1,474	837	1,668
15	800		831	1,424	827	1,125
17	800		793	1,474	855	1,125
		Average outturn . .	810	1,457	839	1,305
14	800	Unmanured . .	819	1,449	1,333	2,849
16	800		793	1,363	840	1,531
18	800		855	1,351	883	1,665
		Average outturn . .	822	1,387	1,018	2,015

Statement showing the outturn of Kesari, Grain and Straw in the experiment with bone manure.

DUMRAON.

No. of Plots.	Area in square yards.	Special treatment.	1893-94. Grain.	1893-94. Straw.	1894-95. Grain.	1894-95. Straw.
			lb	lb	lb	lb
13	800	No additional manure	1,240	1,363	1,117	1,257
15	800		1,134	1,153	1,073	1,240
17	800		905	967	1,101	1,411
		Average outturn . .	1,093	1,161	1,097	1,302
14	800	Unmanured . .	1,166	1,214	1,382	1,819
16	800		1,066	1,104	1,364	1,759
18	800		892	930	1,365	1,812
		Average outturn . .	1,041	1,082	1,370	1,797

Dumraon.

(2) In another experiment at the same farm wheat has been grown on five plots of land; one received no manure, two have had 6 maunds of bone meal, and two 6 maunds of bone meal and 3 maunds of

saltpetre. Statement No. VIII. exhibits the results. It is seen that the outturn on the plots to which bones were applied is rather less than where no manure at all was used, though the difference is not greater than one would expect to find from two different plots quite irrespective of any manurial treatment. From the two plots to which saltpetre was applied in addition to the bone meal the outturn was very much larger. Thus, so far as this experiment goes, there is no doubt that bones produced no increase, whilst saltpetre added about 30 per cent. to the outturn.

Statement No. VIII.—Showing outturn per acre of Wheat in the experiment with bone meal.

DUMRAON.

No. of Plots.	Area in square yards.	Special treatment.	1894-95. Grain.	1894-95. Straw.
			lb	lb
31	800	No manure	402	701
28	800	Bone meal at 6 maunds per acre.	394	692
30	800		390	682
		Mean .	392	687
27	800	Bone meal, 6 maunds, and Saltpetre, 3 maunds, per acre.	523	880
29	800		544	927
		Mean .	533	903

(3) At the Burdwan Farm two plots have been manured with bones and two plots left unmanured, the crop grown being rice. Statement No. IX. contains the results. In this case the bone meal has produced a very considerable increase in the crop, which has been more than double on the manured than on the unmanured land. **Burdwan.**

(4) In another experiment (*vide* Statement No. X.) at the same farm, bone meal, and cattle manure have been applied for the jute crop; one plot has remained without manure. Regarding the rates at which the manures have been applied, the cattle manure has probably contained far more Nitrogen and considerably less phosphates than the bone meal. The bone meal has only produced about as much jute per acre as was obtained from the unmanured land *at first.* After bearing three crops, this unmanured land failed to produce a crop at all. There is no such decrease in productive power observable in the case of the land manured with bones, and it is probable that they have at any rate kept the land up to its normal standard. But a much greater yield has been obtained from the cattle manure which must be referred to the Nitrogen it contains, since the amount of Phosphoric acid has probably been much less than that supplied by the bones.

Statement No. IX.—Burdwan Farm—Paddy.

Number of Plots.	Area in Cottahs.	Treatment with reference to manure. Quantity applied per acre.	Outturn per acre. 1891-92. Grain.	1891-92. Straw.	1892-93. Grain.	1892-93. Straw.	1893-94. Grain.	1893-94. Straw.	1894-95. Grain.	1894-95. Straw.
			lb	lb	lb	lb	lb	lb	lb	lb
68*b*	9	Unmanured	1,799	2,662	1,255	1,666	1,646	3,291	1,467	2,743
69*b*	9	Bone meal, 3 maunds	3,838	4,722	3,703	4,937	4,521	6,295	3,826	5,993
70*b*	9	Bone meal, 3 maunds	3,914	4,758	3,826	4,937	3,703	5,801	4,637	6,267
71*b*	9	Unmanured	1,892	2,748	1,481	2,469	1,786	2,332	1,574	2,061

Statement No. X.—Burdwan Farm—Jute.

Number of Plots.	Area in Cottahs.	Treatment with reference to manure. Quantity applied per acre.	Outturn per acre. 1889-90.	1890-91.	1891-92.	1892-93.	1893-94.	1894-95.
56*a*	4¼	Bone meal, 3 maunds	...	...	...	1,220	1,191	1,220
56*b*	6¼	Cow dung, 150 maunds	2,333	2,488	1,382	1,679	1,777	1,721
59*a*	2½	Unmanured	1,234	1,306	686	Failed.	Failed.	Failed.

M. 237-59.

(5) At Poona in the sugar-cane experiments bones and bone superphosphate are applied to two plots, and these manures *plus* saltpetre are applied to two others; only the first year's outturns are published, and these are given in Statement No. XI. for the four plots which are manured with bones. Poona.

The weight of sugar from the plots manured with bones, bone superphosphate and bones and saltpetre are far below what was obtained with poudrette and oil-cakes; that from the plot receiving superphosphate and saltpetre about equalled these. But the cost of such large applications of bones is now quite prohibitive, and it has become necessary to reduce the quantity very materially.

The large outturn from Plot 11 is possibly due to the Nitrogen in the superphosphate being in a more readily available form. It will be observed that from bones the lowest outturn is obtained; then a larger outturn is obtained from bones and saltpetre and bone superphosphate, both containing more readily available Nitrogen than in the bones alone, and the highest yield is obtained from the dissolved bones and saltpetre in which the amount of readily available Nitrogen was the highest. In any case the large amount of Phosphoric acid has not shown itself of any advantage.

Statement No. XI.—Comparative Manures—Plots ⅛ acre each— POONA.

No. of Plot.	Kind of manure.	1894-95.		
		Weight of manure per acre.	Nitrogen per acre.	Weight of *gul* per acre.
		Tons.	lb	lb
4	Bone meal	5	420	6,945
5	Dissolved bones	6	434	9,870
10	Bone meal and saltpetre	2·5 + 1·0	210 + 207 = 417	9,975
11	Dissolved bones and saltpetre	3 + 1	217 + 107 = 424	13,225
12	Poudrette	42	847	13,270

(6) At the Nagpur Farm, wheat has been grown on two series of plots with different manures. The plots of each series correspond in the matter of manuring and cultivation, the only difference being that Series A is *not* irrigated artificially, whilst Series B *is* irrigated. Nagpur.

For Series A we have 10 years' results and the averages of the first and second five-year periods occupy the first part of Statement No. XII.; the Series B was commenced in 1890, and we have only five years' results, the mean of these being placed in the second portion of the statement. The result of these experiments is fairly uniform throughout. From an application of 360lb of bone-dust there has been

obtained hardly any increase over the outturn of the unmanured plot, from the plot to which saltpetre is applied a very considerable increase is obtained, whilst when we add the bones to the saltpetre, only a slight further increase is obtained, due probably to the Nitrogen of the bones.

Statement No. XII.—Experiments on the value of manures for wheat,
NAGPUR.
Area of each plot—0·10 acre.

No. of Plot.	Kind of Manure.	Series A, Unirrigated. Outturn per Acre. Average of five years, 1885-89. Grain.	Series A, Unirrigated. Outturn per Acre. Average of five years, 1885-89. Straw.	Series A, Unirrigated. Outturn per Acre. Average of five years, 1890-94. Grain.	Series A, Unirrigated. Outturn per Acre. Average of five years, 1890-94. Straw.	Series B, Irrigated. Outturn per Acre. Average of five years, 1890-94. Grain.	Series B, Irrigated. Outturn per Acre. Average of five years, 1890-94. Straw.
7	Unmanured	799	1,297	418	796	486	820
2	Bone-dust, 360℔ per acre . .	891	1,388	534	882	626	954
1	Saltpetre, 240℔ per acre . .	1,133	1,711	751	1,468	931	1,789
3	Saltpetre, 240℔ and bone-dust, 360℔ per acre.	1,094	1,751	865	1,538	1,012	1,924

(7) At the Cawnpur Farm four series of plots are employed to test the value of different manures for the wheat and maize crops. On one series of 13 plots wheat is grown every year, on a second series of 13 plots maize is grown annually; on the remaining two series of 13 plots each maize and wheat are grown in alternate years, wheat being grown on one series in the same year as maize is grown on the other series. The manures for the corresponding plots of each of the four series are the same, thus Plot No. 1 of each series is manured with cow-dung and bone-dust every year just before the particular crop is sown. There is no plot which is manured with bone meal *alone*, but the value of bones is discernible from the comparative results of certain plots which are supplied with bones and cattle manure and bones and sheep-dung. In the Statement No. XIII. are set out the mean outturns of maize and wheat obtained on certain of the plots. The experiments have been in progress for 14 years, but only the last 12 years are suitable for drawing conclusions from; also in 1887 and 1888 the maize was a failure and these years have been excluded for that crop, and as the Plot No. 10 was only included in the experiments in 1884, the results obtained on plot No. 7 are taken for the same 9 years in the case of maize and for the same 11 years in the case of wheat as are available for Plot No. 10. Plot No. 3 is comparable with No. 1; Plot No. 10 may be compared with No. 7, since in each case bone meal is applied in addition to the dung on one of the pairs. Plot No. 6 compared with No. 5 shows the value of bone superphosphate. It will be seen that the bone meal applied to Plot No. 1 in addition to dung has increased the maize crop on both series of plots; in the case of wheat, the crop has been increased on the "Standard" series of plots, whilst there has been a decrease on the "Duplicate" Series. The results obtained with bone meal on Plot No. 7 is less regular, there has been an increased outturn of maize on the "Standard" Series, and a decrease on the "Duplicate"; likewise in the case of wheat there has been a less outturn on the average on the "Standard" Series, and an increased outturn on the "Duplicate" where bone meal has been added to the dung. Of course, strictly speaking, there should have been at least as much grain obtained where bone meal was applied as where it was not applied, but in such experiments as these, and especially when one deals with a manure of such variable nature as cattle dung, exact results cannot be expected. On the whole, whilst there is some evidence that bone meal has added to the crops, the gain has not been very great.

Turning now to the third pair of plots, on one of which 3 maunds of saltpetre, on the other 3 maunds of saltpetre *plus* 3 maunds of bone superphosphate has been applied, it is seen that the superphosphate has uniformly increased the crop, though here also the gain is not great. Superphosphate is, moreover, very expensive in India at present. It may be safely asserted that the same quantity of bones (as superphosphate), would have produced a very much larger return had it been employed for root crops in Europe.

Statement No. XIII.—Cawnpur Experiments.

No. of Plot.	Manure employed.	Maize.		Wheat.	
		Average of 10 years, 1883-86 ; 1889-94, "Standard" Series of plots.	Average of 10 years, 1883-86 ; 1889-94, "Duplicate" Series of plots.	Average of 12 years, 1883-84 to 1894-95, "Standard" Series of plots.	Average of 12 years, 1883-84 to 1894-95 "Duplicate" Series of plots.
		lb	lb	lb	lb
3	Cattle Dung, 180 maunds . . .	1,103	931	1,419	1,705
1	Cattle Dung, 180 maunds and Bones, 4½ maunds.	1,372	1,007	1,506	1,600
10	Sheep Dung, 180 maunds . . .	*1,128	*1,270	†1,476	†1,607
7	Sheep Dung, 180 maunds and Bones, 4½ maunds.	*1,364	*1,045	†1,404	†1,644
5	Saltpetre, 3 maunds	946	767	1,402	1,602
6	Saltpetre, 3 maunds and Bone Superphosphate, 3 maunds.	1,131	874	1,477	1,749

* Average of 9 years.
† Average of 11 years.

Indeed it is doubtful whether it would pay the Indian cultivator to grind up the bones to use as manure for cereals, for this will cost fully R1 per maund.

51. The results obtained at the different farms, excepting the single case of the rice crop at Burdwan, show that the increased outturn of cereals is but very small, it is doubtful if one can depend on a definite increase at all. This is also in accordance with the lesson which the Rothamsted and Woburn experiments have taught in England, namely, that it is the root crop which will respond largely to an application of phosphates, whilst cereals are particularly benefited by one of Nitrogen; and here in India the experiments uniformly show that the cereals and millets are similarly benefited by a nitrogenous manure. It may be also added that, so far as the experiments have gone, there is fairly uniform evidence indicating that the same holds good for sugar-cane. Until, therefore, we find that bones are of *considerable* value to some particular crop in India, it can hardly be said that their export constitutes any serious loss to the ryot. It is not suggested that further experiments on the manurial value of bones should be discontinued. On the contrary, experiments are being commenced to test their value for both oilseeds and potatoes, and roots will also be included as soon as the necessary arrangements can be made. Oilseeds and potatoes are largely cultivated; swedes are extensively grown in the Panjab, and carrots are grown commonly in the North-Western Provinces.

VI.—SALTPETRE.

52. The value of saltpetre as a manure is well recognised in Europe, and if its virtue in this respect is not also known in India, it is certainly applied *indirectly* as a manure. There is hardly any need to go into details of its value in this place. In *The Agricultural Ledger No. 14 of 1895* (Medical and Chemical Series, No. 2) is set out the composition of a number of well waters, from Gujerat (Bombay) containing high proportions of nitrates which are known to the people to be of great value to the tobacco crop, and the water is annually sold at certain rates by the proprietors of the particular wells.

Saltpetre has also proved itself at the farms to be a valuable manure. Its value is probably almost entirely due to the Nitrogen it contains. I have not found Indian soils wanting in potash. One or two analyses of the saltpetre generally met with in the bazars may be here appropriately quoted, Composition.

Statement No. XIV.—Composition of Samples of Saltpetre.

Moisture	5·80	11·87	1·55	·60
Nitrate of Potash	48·90	35·01	94·91	94·80
Sodium Chloride	30·82	26·94	1·93	3·83
Sodium Sulphate, etc.	10·53	14·90	1·21	·57
Sand	3·95	11·28	·40	·20

Price.

The greater number of samples, which I have analysed, are decidedly impure and usually contain a lot of common salt with a little sulphate. The first and second analyses in the statement represent two samples of *very* low quality, the third and fourth two of very high quality. The price and purity of saltpetre vary considerably in different places, sometimes it can be bought for R3 per maund, sometimes it will cost R10, the price being generally (though not always) indicative of the purity.

For example, two samples obtained at Poona this year were priced at R8-4 and R8 per maund, while they contained 85 and 60 per cent. of nitrate of potash respectively. It is in any case a very dear manure; its Nitrogen costs about three times as much as the Nitrogen in some oil-cakes or in poudrette.

Village nitre-earth.

53. ***Village Nitre-earth.***—It is probable that in villages generally saltpetre forms in the gutters and wherever drainage collects, and nitrification can proceed. Saltpetre is frequently extracted from this, but in other cases this earth is applied as a manure. Three samples of nitre earth, which I have received from Cawnpur, contained 2·52 per cent., 2·90 per cent., and 2·18 per cent. of nitrate of potash.

VII.—THE SILT OF RIVERS, CANALS AND TANKS.

54. There is probably no more generally applied "manure" in India than the silt of rivers and canals, and of tanks also where they are common. The term "manure" must be admitted here, because its meaning may be said to be essentially "an application of plant food to the soil," although, on the other hand, the amount of that plant food which silt contains in a given weight is very small compared with most other "manures." When one bears in mind the very remarkable part which water plays in many parts of India during the monsoon periods, when the surface wash, whether from hill sides or from more level lands, is so great that clear water is not to be seen, it will be apparent that vast quantities of earth of one description or another are transported, and in part deposited at lower levels. In some cases an absolute loss to the cultivator occurs, in others he is the gainer. It is not a part of the object of this paper to enter upon this transference of soil, excepting with the one purpose of illustrating how it may become an agent for enriching the land.

In the first place since India generally has only a comparatively small supply of manures, even poor ones are of advantage in at least assisting to maintain the fertility of the soil. Especially in the case of canals is this deposition of silt a regular feature. Rivers more frequently take silt *from* the cultivated lands, but in those parts where they either flood the country annually as in Eastern Bengal, as likewise where they are dammed up and brought over the land by the people, as in some of the Eastern Districts of the North-Western Provinces, they *must* be adding to its fertility. Where tanks are employed as irrigation agents the mud which collects in them has been transported from the hills and is frequently dug out and

applied to the land as a fertiliser. At the same time *all* silt carried by rivers is not a blessing. If it consists principally of sand, it will probably do harm rather than good. Such, for instance, is the case in the Hoshiarpur District of the Panjab, where enormous amounts of sand are brought down from the hills during the monsoon and cover up the good soil. Exact information as to the agricultural value of silt is almost entirely wanting. Some experiments are at present being made to estimate the value of silt brought on to the land by canal water, and the first year's results have gone to show that the amount of plant foods, Nitrogen and Phosphoric acid, in the silt of the Eastern Jumna canal water is more than is taken from the soil by the rice crop, but is considerably less than what an average wheat crop will take up and very far less than what a sugar-cane crop requires. Incidentally this result coincides with the general practice in regard to rice cultivation in India. Rice lands are rarely manured. They are usually clays, and the water passes from one field to another, removing and also, at the same time, depositing silt. Thus rice lands may be said to annually receive a certain amount of silt from higher levels, and this may prove to be an explanation of why they can do without manure better than any other sort of lands.*

Agricultural value of silt.

Rice lands.

VIII.—GREEN MANURING.

55. If a crop be grown and then, whilst green and immature, it be ploughed in, the land will be enriched with organic material, and rendered more open and its quality may be thereby improved for a succeeding crop. This process is styled "green manuring." Indian soils are so generally poor in organic matter that it may be said the process is especially beneficial to them. Another advantage probably accrues, for whilst a crop is growing, some portion of its plant food will come from sources which are considered "less available," *i.e.*, less readily assimilated than that which is "readily available," and when the plant is destroyed and it decays, this plant food, which may be said to have been obtained with difficulty by the green crop, will be readily "available" to the succeeding one. Thirdly, the green crop will take nutriment from the sub-soil, and this will be deposited at the surface when the crop is "ploughed in." Thus in such a case it may be said that the green crop adds organic material to the soil, increases the readily available plant food and carries plant food from the sub-soil to the surface; a point of some value to the young plant. If the green crop belong to the sub-order PAPILIONACEÆ (nat. order LEGUMINOSÆ) it is probable that it will, in addition to the above, effect an absolute increase not only of carbonaceous matter, but likewise of Nitrogen from the atmosphere. This property of the pea family of plants has been sufficiently fully dealt with in *The Agricultural Ledger No. 7 of 1894* (Agricultural Series, No. 8), and requires no further explanation here.

Objects added organic materials.

Increase of available plant food.

Plant food brought from sub-soil.

Assimilation of atmospheric Nitrogen.

* *Note.*—Since writing the above the details of the experiments with canal silt have been published in *The Agricultural Ledger No. 5 of 1897*—*J. W. L.*

Agricultural experiments.

Experiments to test the value of the process of ploughing-in green crops have been in progress at the Cawnpur and Nagpur Farms for a number of years, and the principal results have been published in *The Agricultural Ledger No. 3 of 1894* (Agricultural Series, No. 7, pages 8 to 12). The results of two more years are now obtainable, but no good purpose would be fulfilled by recapitulating them. It need only be stated that these newer figures corroborate those referred to (*l. c.*) at Cawnpur, and since the attacks of rust have not been severe at Nagpur during the two additional years (1893-94 and 1894-95), the results obtained at that farm are more concordant than they were. Much will naturally depend on whether the "green crop" grows well or not. If it is more or less of a failure, its value as a manure will naturally be small. At Cawnpur the increase in the wheat crop due to this system of manuring has generally been several hundred pounds per acre; at Nagpur it has varied much according to whether the wheat has been affected by rust or not, but in the years of good wheat harvest, the increase has amounted to between 100 and 200lb of grain. How far this method of manuring is practicable to the ordinary cultivator is, however, a question which cannot be said to have been answered altogether. The practice is adopted in some places.

IX.—THE ASSIMILATION OF NITROGEN BY PAPILIONACEÆ.

Conf., Agricultural Ledger No. 7 of 1894.

56. In paragraph 60 of Dr. Voelcker's Report on the Improvement of Indian Agriculture it is pointed out how extensive is the cultivation of plants of the leguminous order, and the question is raised as to how far their presence is assisting to maintain the supply of Nitrogen to the soils of India. Experiments have been in progress at the Cawnpur Farm for about 15 years to test the effect of the indigo and *san* hemp crops in this respect. The crops are grown in the monsoon, then removed, and wheat is then sown on the same plots in the following *rabi*. The results with *san* hemp are so discordant as to become valueless; those for indigo are better, and are contained in Statement No. XV.

Cawnpur experiments.

Statement No. XV.—Experiments to test the value of Indigo for the succeeding Wheat crop—Outturn of grain in lb.

	1883-84.	1884-85.	1885-86.	1886-87.	1887-88.	1888-89.	1889-90.	1890-91.	1891-92.	1893-94.	1894-95.
Wheat after Indigo .	1,590	1,107	1,791	1,283	1,379	835	1,988	1,136	1,258	696	287
Unmanured .	1,514	623	1,367	847	786	653	1,464	1,162	690	877	287
Increase (or decrease)	+76	+484	+424	+434	+593	+182	+524	—26	+568	—181	...

It is seen that, so far as this experiment goes, there is a very considerable increase in the greater number of years. Indigo planters generally, I believe, recognise that the crop is beneficial to the succeeding wheat, and it is possible that the results of the above experiment are not accidental. At the same time they require very careful verification, because if they do not overstate the case, one would have thought the cultivator would have found out the great value of the process and applied it generally for wheat. Similar experiments are being made with several other papilionaceous crops at Cawnpur, but no results are available at present.

X.—SHEEP FOLDING.

57. The practice of penning sheep and goats on cultivated land with the object of manuring it for a succeeding crop is practised extensively in some parts of India, especially in Bombay and Madras Presidencies. It is a most valuable method and it is common (I believe) for cultivators to pay the herdsmen to keep their flocks on the land. Precise information of the practice is, however, not in my possession.

CONCLUSION.

58. In the foregoing paragraphs such information regarding the properties of the various "manures" which are (or might be) available to the cultivator, as is at the writer's disposal, has been set out; the chemical composition has been explained, and the results of growing certain crops experimentally with these manures have been stated. There still remains one point, namely, the *quantity* of these several substances, about which a few words may be said in conclusion. Incidentally figures have been stated when dealing with the several materials indicating quantities per acre or, as in the case of oilseeds and bones, the amounts exported.

One might go further and calculate from the approximate weight and composition of the various crops grown, the probable amount of fertilising matters which the various manures will be equivalent to. The data are, however, not very exact, and it is, perhaps, unnecessary. In paragraph 1 it is stated that the manure supply of India must be considered as obtainable, for all practical purposes, from materials produced *in* India. The only "manure" which comes from outside is the silt brought by rivers and canals, whilst this source of plant food is not very small in amount, it is but little when compared with the whole. The area irrigated by canals is 10,900,000 acres, that from rivers, tanks, etc., 7,300,000 (*vide* Statistical Atlas of India), both of which are sources of silt deposit. The total cultivated area is 220,000,000 acres, so that less than one-tenth of the cultivated area is thus more or less replenished from outside.

But for the rest, it must depend on *the simple return*, more or less perfectly carried out, *of the plant food which the crops grown, extract from the soil.* If this fact be borne in mind, it must be admitted

that *the* principal source of manure *must* be the excrements of the people and animals. It *may* be that the leguminous plants are exerting a material influence, and this is a subject very well worth careful investigation both in the field and in the laboratory. At present we do not know even which plants of this natural order assimilate Nitrogen and which (if any) do not. Much less complete is our information regarding the comparative powers of these plants to assimilate this plant food. The exports of oilseeds, bones, etc., must in any case be admitted to fall into insignificance by the side of the various animal manures. It is the more perfect recovery of these excrementitious matters which will gradually increase the manure supply generally, and it is in this direction that the most useful work may be done. Whether a better fuel supply can be gradually produced so as to save the cattle dung; whether the urine may be more readily collected for direct return to the land; whether night soil and sweepings may be applied to larger areas than is at present the case, may be said to be really the main questions which require practically working out.

M. 237-59.

G. I. C. P. O.—No. 246 A. & R. D.—6-8-97-2,200—W. B. G.

All communications regarding THE AGRICULTURAL LEDGER should be addressed to the Editor, Dr. George Watt, Reporter on Economic Products to the Government of India, Calcutta.

The objects of this publication (as already stated) are to gradually develop and perfect our knowledge of Indian Agricultural and Economic questions. Contributions or corrections and additions will therefore be most welcome.

In order to preserve a necessary relation to the various Departments of Government, contributions will be classified and numbered under certain series. Thus, for example, papers on Veterinary subjects will be registered under the Veterinary Series; those on Forestry in the Forest Series. Papers of more direct Agricultural or Industrial interest will be grouped according as the products dealt with belong to the Vegetable or Animal Kingdom. In a like manner, contributions on Mineral and Metallic subjects will be registered under the Mineral Series.

This sheet and the title-page may be removed when the subject-matter is filed in its proper place according to the letter and number shown at the bottom of each page.